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THE CHINCH BUG AND ITS CONTROL

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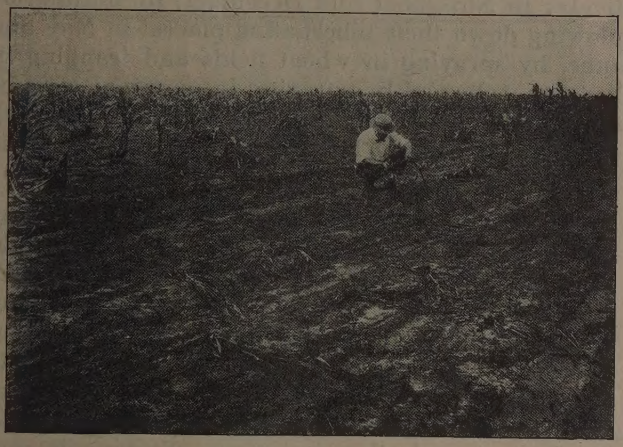

Corn Plants Killed by the Chinch Bug

Contribution from the Bureau of Entomology
L. O. HOWARD, Chief

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CHINCH BUGS destroy fully $46,000,000 worth of corn, wheat, oats, and forage sorghums in the United States every year.

Aggressive work against these insects is more profitable than defensive work. There are three periods when they may be destroyed most effectively: In November and December, by burning or plowing down their hibernating places; in May and June, by spraying in wheat fields and trapping in barriers, followed by spraying in marginal rows of corn if necessary; and in September, by plowing corn stubble deeply before the bugs have gone to winter cover.

Chinch bugs spend the winter largely in bluestem and other bunch grasses, in pastures, neglected fields, roadsides, sunny hill slopes, and similar uncultivated places. The grasses should be burned in November and December, and unused areas kept as clean as possible. The bugs leave their winter quarters in early spring, migrating to fields of wheat, oats, etc., feeding until the grain is nearly ripe and then attacking the corn and other row crops. Serious damage to row crops can be prevented by spraying the bugs themselves with oil-emulsion nicotine sulphate as described in this bulletin. Countless millions more may often be destroyed by using these same means in the wheat stubble, immediately following the binder.

Cooperation in conducting chinch-bug control measures in neighborhoods or larger blocks is of vital importance.

THE CHINCH BUG[1] AND ITS CONTROL.

CONTENTS.

	Page.
Amount of damage	3
How the chinch bug injures crops	4
Where the chinch bug occurs	4
How to know the chinch bug	5
The adult	5
The egg	7
The young	7
Food plants	8
Life history	9
Winter quarters	9
Migrations	10
Generations	11
Conditions favoring outbreaks	12
Natural control	12
Natural controls not dependable	12
Diseases	13
Predacious and parasitic enemies	14
Control measures	15
Measures must be adapted to the conditions	15
Control measures—Continued.	
Equipment	16
The season's campaign	27
Trap strips between winter quarters and wheat	28
Trap strips between wheat and corn	28
Spraying the bugs in wheat	29
Spraying the bugs in corn and trap crops	29
Substituting nonsusceptible crops for corn and sorghum	30
Operation of barriers	31
Plowing the bugs under in wheat stubble and corn	33
Cooperation	33

AMOUNT OF DAMAGE.

ABOUT the year 1783 wheat crops were destroyed by the chinch bug in Orange County, N. C. In 1785 it had so spread and increased that the total destruction of wheat was threatened. For four or five years it spread and increased in North Carolina and Virginia, causing great loss both to wheat and corn. About 1809 the damage was so intense in Orange County, N. C., that wheat growing was abandoned for two years, with the result that the pest was subdued.

In 1839 it was again very destructive in Virginia and the Carolinas, completely wiping out oats and wheat, except an especially early maturing variety, and severely damaging corn. In 1840 it became destructive to wheat and corn in Illinois, breaking out again in 1844 and 1845. It was destructive in Iowa in 1847 and in Indiana in 1848. In 1854 it was a scourge in Illinois, Indiana, and Wisconsin, and continued to be destructive in Illinois till 1858.

The outbreak of 1863–1865 in Illinois was estimated to have caused the loss of about 30,000,000 bushels of wheat (three-fourths of the crop) and 138,000,000 bushels of corn (one-half of the entire crop), the cash loss being computed at $73,000,000.

[1] *Blissus leucopterus* Say; order Hemiptera, family Lygaeidae (Myodochidae).

Two other outbreaks for which the losses were estimated were those of 1871 and 1874, in which the ravages of the insect were enormous and widespread throughout the States of Indiana, Illinois, Wisconsin, Missouri, Iowa, Nebraska, and Kansas. The loss in 1871 in these seven States has been computed at $30,000,000. In Missouri alone the loss in 1874 was computed at $19,000,000, and for the seven States at upward of $60,000,000.

The next serious outbreak for which the losses were estimated occurred in 1887 in Kentucky, Ohio, Indiana, Illinois, Wisconsin, Minnesota, Iowa, Missouri, and Kansas. The damage in this year amounted to $60,000,000, the greatest loss occurring in Illinois, Iowa, Missouri, and Kansas.

In the years 1892 to 1897 an outbreak in Kansas, Iowa, Minnesota, and Illinois, reaching its maximum in Ohio in 1896, caused a loss estimated at not less than $2,000,000 for the last-named State alone.

The total estimated loss in the United States for the period from 1850 to 1915 is placed at fully $350,000,000. In round numbers this is at an average yearly rate of $5,385,000 during the entire period of 65 years.

The average annual loss sustained by the most heavily infested States taken as a whole has been estimated at 5 per cent of the wheat crop and 2 per cent of the corn crop. On the basis of the average farm value of the foregoing crops for the years 1912, 1913, and 1914, at normal prewar prices, the annual loss in the wheat crop would be $20,000,000; in the corn crop, $24,000,364; in the grain sorghums, $2,009,985; and in broom corn, $94,000. The total annual loss to the farmers of the United States from chinch bug depredations in these crops would, therefore, run upwards of $46,104,349.

HOW THE CHINCH BUG INJURES CROPS.

The chinch bug feeds upon growing crops throughout its entire life. It is armed with a four-jointed beak, equipped with lancets for piercing the plant and starting the flow of sap, which is sucked into the stomach. In feeding it imparts a reddish stain to the plant parts attacked and causes the death of plant cells. The feeding of a large number of bugs on growing plants prevents normal growth and brings about a dwarfing or falling of plants and a reduction of yields. A concerted attack such as often occurs in young corn and forage sorghums may kill the plant outright or so weaken it that it remains small and fails to yield at all.

WHERE THE CHINCH BUG OCCURS.

The principal distribution (fig. 1) of the chinch bug in North America extends from the Rocky Mountains eastward to the Atlantic Coast, and from Manitoba to Texas. The States in which destruc-

tive outbreaks occur are: Texas, Arkansas, Oklahoma, Kansas, Nebraska, Wisconsin, Iowa, Minnesota, Illinois, Missouri, Kentucky, Indiana, Ohio, South Carolina, North Carolina, and Virginia. In the following localities in the mountain district it is known to be present, but does not occur in destructive numbers: New Mexico and Arizona; California, in the Sacramento, San Joaquin, and southern Imperial Valleys; and Washington. It has recently been reported from the Missouri River Valley in northeastern Montana. It has been found in Connecticut, Maine, Massachusetts, Tennessee, South Dakota, Louisiana, Florida, New Jersey, Pennsylvania, and New York. It has also been discovered in places in the West Indies, Cuba, Panama, Guatemala, Lower California, Mexico, Cape Breton, and Canada.

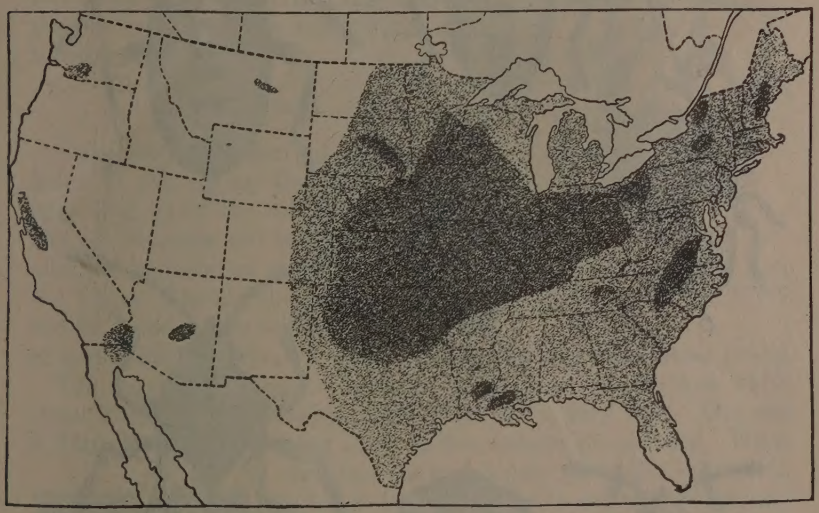


FIG. 1.—Map showing distribution of the chinch bug and areas most often devastated by it.

HOW TO KNOW THE CHINCH BUG.

THE ADULT.

The full-grown or adult chinch bug (figs. 2, *f;* 3) is the first form of this insect to be found in the spring. At first very few are seen, as they resume activity gradually, leave their winter quarters, and attack the growing crops. They fly and crawl to the young wheat and may be found well down in the wheat stools almost any time during April and May.

Two forms of adult occur, one having short wings which reach only from one-half to two-thirds the length of the abdomen, the

other having long wings which reach almost to the tip of the abdomen. The long-winged form (fig. 2, *f*) occurs over most of the country between the Rocky Mountains and the Allegheny Mountains.

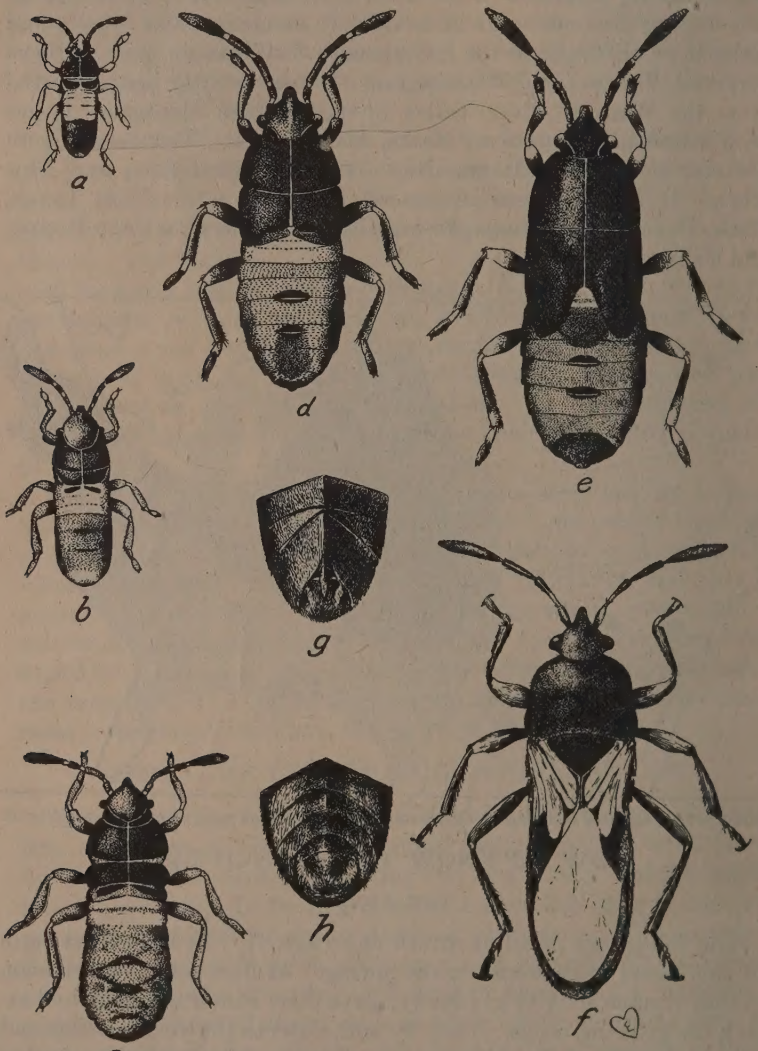


FIG. 2.—The chinch bug: *a–d*, First to fourth instars, respectively; *e*, pupa; *f*, adult female, long-winged form; *g*, genitalia of the female; *h*, genitalia of the male. Greatly enlarged. (Luginbill.)

The short-winged form (fig. 3) has been found to exist principally along the seacoast, and in the East extends inland along the lower Great Lakes to Northern Illinois. It is not abundant, however,

west of a line drawn from Toledo, Ohio, to Pittsburgh, Pa. The long-winged form mingles with the short-winged form throughout the territory occupied by the latter. Both forms are white immediately after the skin is shed, but soon become black. The upper wings are whitish at the base, white at the tips, and bear a black spot about the center. The under wings are whitish, folded membranes. The insect is about one-fifth inch or less in length.

The adult may be easily distinguished from the young or nymph by its larger size, the possession of four wings, and the absence of pink or red coloration. It does not differ greatly in size and color from the large nymphs in the last stage of growth, but its whitish upper wings make identification easy.

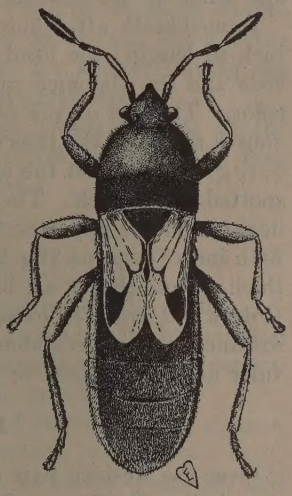
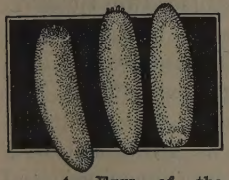


FIG. 3.—Chinch bug adult, short-winged individual. Greatly enlarged.

THE EGG.

Soon after transferring to the wheat fields in the spring the bugs lay their eggs (fig. 4) in the soil about the roots and on the roots and stems of the wheat, also particularly on the lower leaves of the wheat. During the summer the eggs can be found in the soil around the roots of corn, kafir, and similar crops, and on the roots and basal leaves.

The average egg length is about 0.033 inch, the average width about 0.012 inch. It is shaped somewhat like a navy bean. One end is flattened and bears from three to five minute projections. When first laid the egg is pale yellowish, but within a day or two it darkens to an amber color, and finally shows the red coloring of the little insect within. The size sometimes increases to nearly 0.04 inch before hatching.



4.—Eggs of the chinch bug. Greatly enlarged.

THE YOUNG.

The chinch bug undergoes six transformations or stages after emerging from the egg, at least in South Carolina, where it has been studied most carefully. Almost immediately upon issuing from the egg, the little reddish nymph (fig. 2, *a*) starts feeding and locates where it is sheltered from the sun, rain, and its natural enemies. The insect moves about from place to place throughout its life, and hence may be found in various positions, ranging from the tip to the

roots of the food plant upon which it lives. During the summer the bugs may be found among the roots just beneath the surface of the soil, under leaf sheaths, in the leaf curls, and in the heads of such crops as corn, kafir, milo, feterita, Sudan grass, etc. They may also often be found under clods of earth, fallen leaves, and almost any other shelter existing between the rows of corn or other crops.

Immediately after hatching, the young chinch bug is about 0.04 inch in length; the head and thorax are brown; the eyes are dark red; and the abdomen ranges from yellowish white to light red in color. The tip of the abdomen is black. The second, third, and fourth stages of the insect are similar to the very young bugs (fig. 2, *b*, *c*, *d*), except that the abdomen becomes a darker red in color and spotted with black. The wing pads appear in the fourth stage or instar, and the abdomen becomes banded with red and black. The fifth instar or pupa (fig. 2, *e*) is about one-sixth of an inch in length, the head and thorax are black and polished, and most of the abdomen is dark red, with the exception of the tip, which is black. At a little distance the entire abdomen appears black. The sixth stage is the fully developed insect or adult.

FOOD PLANTS.

Over the western part of the country, from Indiana to Texas, the principal crops damaged are wheat, field and garden corn, the millets (including Hungarian grass),[2] and the sorghums,[3] including cane, kafir, milo, broom corn, shallu, feterita, Sudan grass, kaoliang, and durra. An outbreak usually originates in wheat, rye, or barley fields, from which the bugs migrate to near-by fields of corn and sorghum, beginning shortly before the small grain is ripe and passing over in great numbers shortly after it is harvested. In the northeastern part of the country, where the forage sorghums are replaced by timothy, the migrating bugs are quite as likely to be attracted to the timothy meadows as to corn, where both are within equally easy reach. Rye, barley, and oats are less subject to severe damage than wheat. The chinch bug is said to attack sugar cane in Mexico.

Among its less important food plants may be mentioned such forage grasses as Johnson grass,[4] emmer,[5] spelt,[6] bluegrass,[7] and prairie grasses. The bugs also develop to some extent on such wild grasses as bottle-brush grass,[8] little bluestem,[9] big bluestem,[10]

[2] *Chaetochloa italica*, ssp. *nigrofructa* v. *atra* Hubb.
[3] *Holcus sorghum* L.
[4] *Holcus halipensis* L.
[5] *Triticum sativum dicoccum* Schrank.
[6] *Triticum sativum spelta* Hackel.
[7] *Poa pratensis* L.
[8] *Hystrix patula* Moench.
[9] *Andropogon scoparius* Michx.
[10] *Andropogon provincialis* Lam.

forked beard grass,[11] barnyard grass,[12] oat grass,[13] bur grass,[14] crab grass,[15] Burmuda grass,[16] green foxtail,[17] yellow foxtail,[18] St. Augustine grass,[19] reed,[20] and old witch [21]. It is also said to feed upon a so-called wild buckwheat. It has recently been reported as feeding upon the leaves of the currant in Christiania, Norway.

In Kansas, Oklahoma, and some other Middle Western States, the big bluestem, little bluestem, Johnson grass, and some other bunch-forming grasses are utilized largely for shelter during the winter and as food on the warmer days of early spring.

The insect has therefore an ample food supply outside of the cultivated fields, although when limited entirely to its wild host plants it does not often increase excessively.

LIFE HISTORY.

WINTER QUARTERS.

It is vital to know where the chinch bug passes the winter, because important means of destruction are based on its hibernating habits, and furthermore this knowledge suggests the need of certain farm practices which tend to discourage the insect.

The bugs are most abundant at the bases of bunch-forming grasses, such as bluestem and prairie grass, along hedges, brushy fence rows, ditch banks, roadsides, and woodlands, in meadows, pastures, and ravines, preferring southern slopes and areas south of protecting woodlands or hedges. Where more suitable shelter is not at hand, they sometimes remain in dead and partly decayed stubbles left in the field after plowing, in corn and sorghum shocks, and in standing corn.

Their destructive work usually begins along the edges of fields bordering such places. Again and again serious destructive outbreaks of the pest in wheat fields have been traced directly to the excellent hibernating quarters furnished by shocks of corn, kafir, cane, Sudan grass, and other fodder allowed to stand in the field through the winter. The bug also hibernates in weeds, grass, and leaves along roadsides and edges of cultivated fields, in the angles of worm fences, under loose stones and logs, in rotting stumps, and under newly spread manure, bits of boards, and sacks.

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[11] *Andropogon furcatus* Muhl.
[12] *Echinochloa crusgalli* (L.) Beauv.
[13] *Arrhenatherum elatius* (L.) Mert. & Koch.
[14] *Cenchrus tribuloides* L.
[15] *Syntherisma sanguinalis* (L.) Dulac.
[16] *Capriola dactylon* (L.) Kuntze.
[17] *Chaetochloa viridis* (L.) Scribn.
[18] *Chaetochloa lutescens* (Weigel.) Stuntz.
[19] *Stenotaphrum secundatum* (Walt.) Kuntze.
[20] *Phragmites* sp.
[21] *Panicum capillare* L.

In the Middle West destructive outbreaks are most frequently traced to the abundance of thick, bunch-forming grasses and to the matted grass and leaves bordering osage-orange hedges. In the timothy meadows of New England, New York, and northern Ohio these conditions are of less importance, because there the insects pass the winter largely in the meadows and do not migrate to and from these places, except on foot.

While all sizes of nymphs, as well as adults, go into hibernation places in the late fall, it appears that (except for one record from Montana) only the adult bugs survive the winter.

MIGRATIONS.

The chinch bug always seeks the nearest suitable hibernating place in the fall, and its choice is determined by the necessities of shelter and food. While some bugs may be found at any time in scattered locations where there is no food, as a rule they prefer, especially in the southern part of the range, to get down in the midst of plants such as bunch grass, Johnson grass, or in green fodder stubbles or shocks where some of the plants remain green. They then have food on the warm days occurring after hibernation begins and before they leave their winter quarters in the spring. In the spring the insect moves only as far as is necessary to assure an abundant food supply. In situations such as the timothy fields of northeastern Ohio, it spends the winter in the fields, merely continuing its ravages in the spring. In the fodder fields of southern Oklahoma and Texas it does likewise, when the fields are left in stubble or shocks are left on the ground. In Kansas it often migrates by flight for considerable distances to secure good hibernating quarters in the prairie bunch grass in fall, and from such quarters to the fields of growing wheat in the spring.

In the northern part of its range, the spring movement usually begins in April and continues until the latter part of May. In the southern portion, i. e., Oklahoma and Texas, it begins in the latter part of March or early part of April and continues until the latter half of May, or, in some seasons, until the first part of June. The migration is spread over several weeks, the earliest individuals having deposited eggs before the latest ones have left winter quarters. In their spring search for food they usually attack fields of grasses, wheat, oats, or barley. The adults find feeding places well down in the plant stool, and, as the days grow warmer, along in April or May, earlier in the South, later in the North, begin to deposit their eggs in these situations.

A single chinch bug deposits from 100 to 500 eggs in the course of her life, the average probably being between 100 and 200. The eggs

begin to hatch in late April, from 10 to 25 days after being laid, and continue hatching until June, varying with the locality.

The young bugs, hatching in large numbers in May and June, live in the wheat until it begins to ripen and dry, when they leave it, sometimes in armies, crawling on foot to the nearest corn, kafir, or sorghum field. Here they gather on the first rows in dense masses and do the greatest damage of the year. Their habit of remaining together in populous colonies is responsible for the more severe injury such as the killing of the plant outright. A favorite location for the bugs is on the brace roots of corn, which they sometimes weaken so much that the corn falls down. They grow and feed from the latter part of April until July, or for about 3 months, during which time they outgrow and shed their skins several times. Collections of these gray cast skins may often be found upon corn and other crops where the young chinch bugs have occurred in numbers.

GENERATIONS.

The young usually are accompanied in their migrations by some of the overwintering adults and some adults of the first summer generation. The last of the overwintering adults usually die by early July. The adults of the first summer generation usually mature from the first half of June to the latter half of August and deposit eggs throughout most of this period. The eggs develop into second-generation adults from the middle of August to the last of October. The second generation of adults deposits eggs in August, September, and October, many of which hatch, thus beginning a third generation which, however, appears never to develop beyond the nymph stage and not to survive the winter. Thus it is seen that, at least over most of the range of the long-winged form, the chinch bug has but two full generations, and in the southern portion of its range a partial third generation annually. In the eastern portion of the country, where the short-winged form prevails, it is not certain that there is more than one generation annually.

Throughout the Middle West, where the chinch bug does its greatest damage, crops suffer from two attacks annually, although the second attack is not usually noticed. It must be remembered, however, that this later attack is of the utmost importance, for if there are but few of the second generation developing to adults there can be no serious outbreaks the following season.

Oviposition ceases toward the end of August in the northern part of the chinch bug's range and the latter part of October in the southern portion. The insects congregate in October or early November in temporary shelter in corn and fodder shocks and in the stubble, where they feed until the first few cool days of fall. The young

gradually die off during October and November; the remaining adults then finally seek permanent hibernating quarters for the winter.

CONDITIONS FAVORING OUTBREAKS.

If growers will take the trouble to watch certain field and weather conditions they usually will be able to tell when an outbreak of chinch bugs threatens. The most important among the conditions favoring outbreaks are: (1) Suitable hibernating places, and (2) warm, fairly dry weather during the two critical hatching periods, May to June and August to September.

In the northern and middle range of the insect, it must have hibernating places capable of harboring large numbers of adults in a position well sheltered from natural enemies and disease. Its winter shelter must be dry and must contain sufficient green plant food to tide it over the periods of warm weather that may occur after it has begun hibernating and before the advent of cold weather, and in the spring before conditions are right for migration to its regular food plants. In its southern range its hibernating quarters must supply food for these periods and must be of a sort that will protect it from a succession of warm, thawing days followed by freezing.

Even if these conditions are met and a fairly good percentage of the bugs get safely through the winter, transfer to the grain crops, and have favorable, warm, dry weather for depositing their eggs, a severe outbreak may still be prevented by a series of drenching rains and prolonged wet, humid weather during the hatching periods. These periods are, for the first generation, throughout May, overlapping into June and extending slightly into July, and for the second generation August, overlapping into September, and in the south extending into October.

NATURAL CONTROL.

NATURAL CONTROLS NOT DEPENDABLE.

That the chinch bug can withstand almost every conceivable climatic variation is shown by the fact of its distribution from little north of the equator to nearly 50° north latitude, and from more than 200 feet below sea level, in the Imperial Valley of California, to upwards of 6,000 feet above sea level in the mountain regions. So far as the influence of cold is concerned it is only in the least protected situations that severe winter weather has much effect in reducing the abundance of the pest. Chinch bugs have been known to withstand temperatures of from 15° to 20° F. below zero, even when incrusted with a coat of ice. Undoubtedly they must have hibernating quarters that will afford protection, and they are usually able to find

such quarters. Likewise, the insect can withstand the most severely hot summers, provided it is not long exposed to the direct rays of the sun. In Kansas and Oklahoma large numbers of the bugs are occasionally killed by being knocked from the plants by harvesting when the soil temperature is as high as from 125° to 135° F. In such cases the bugs perish before they are able to travel the 6 to 12 inches to shelter. Most of the bugs escape exposure to such conditions by remaining behind leaf sheaths of corn, kafir, and other crops, or by staying among the roots in soil shaded by the plants, moving from one plant to another only in the late afternoon or early forenoon.

The amount of moisture in the air apparently has no appreciable effect in reducing the abundance of the pest, and it can withstand not only the humidity of the tropics but the continuous drenching rains of more northern latitudes. While it is true that the years of greatest devastation by the chinch bug have largely followed a succession of years of deficient rainfall, the amount of annual rainfall can not be depended upon in predicting outbreaks. Chinch bugs have sometimes been exceedingly numerous and destructive in years of more than normal rainfall. Even if the precipitation occurring only during the active season of the bugs (April to October) is considered, it may fail to give us a basis of prediction. Much depends upon the character of the rainfall.

DISEASES.

The abundance and consequent worth of fungous diseases known to attack the chinch bug are entirely dependent upon the occurrence of wet, cloudy, and cool weather during most of the hatching and growth period of the young bugs. This dependence upon a particular kind of weather ordinarily prevents these diseases from destroying the bugs in large numbers.

The principal disease, known as the chinch-bug fungus,[22] has been purposely introduced among the bugs in Kansas, Nebraska, and Illinois, without practical commercial benefit in preventing damage. Its efficiency depends very largely upon exceptional seasonal precipitation, just the conditions which of themselves alone are most unfavorable to the chinch bug. In seasons when the bug can thrive best least can be expected of the fungus. The disease attacks many other insects, and is present every year throughout most of the chinch-bug territory. Therefore, it would become exceptionally abundant in unusually favorable weather without artificial introduction, whereas cultures introduced in unfavorable weather would be held to the normal level of the disease. The control of the chinch bug by introducing fungous disease has so far failed. Where the

[22] *Beauveria globulifera* (Speg.) Picard.

disease is already present, its destructiveness can not be increased by introducing more diseased material; and where not present, introduced disease has no noticeable effect, as its absence means conditions unfavorable to the fungus.

Another disease [23] which probably attacks the chinch bug has been known since 1888, when it was first discovered in cutworms. In the last three years it has been found attacking a number of different kinds of insects, and its possible usefulness is still under investigation.

PREDACIOUS AND PARASITIC ENEMIES.

While the chinch bug has a considerable number of enemies belonging to the animal kingdom, it is more fortunate than most other insect pests in escaping attack, and, for an insect of such great abundance and wide distribution, has comparatively few natural enemies. None of them appears to prey wholly or even to a large extent upon it alone; none of them appears to be of any great importance in suppressing serious outbreaks. The birds and other higher animals which have been known to eat chinch bugs feed upon almost all kinds of insects, and thus destroy only an occasional individual of this kind.

Its most important natural enemies are undoubtedly other insects, twenty or more kinds of which are known to attack it occasionally or habitually. The most important of these are lady beetles, ground beetles, true bugs, the young of the lace-winged flies, and ants. A great majority, if not all of them, feed widely upon many kinds of insects, and are by no means especially destructive to chinch bugs. The most important predatory enemies are probably the insidious flower bug,[24] the many-banded assassin bug,[25] and several kinds of ants. Both the insidious flower bug and the assassin bug, however, have a multitude of other victims, and even when numerous among the chinch bugs have never been seen noticeably to reduce their numbers. The false chinch bug,[26] which often occurs on field and garden crops in extremely large numbers, also feeds occasionally on young chinch bugs, but it is almost entirely a plant-feeding insect. Ants are more numerous than all other animals put together and probably cause the death of more chinch bugs than any other enemy.

Only two truly parasitic insects, living within the body of their host, assail the chinch bug. One of these is known as the chinch-bug egg parasite,[27] and has been credited at one time with annihilating from 16 to 50 per cent of the eggs in Kansas. The other is a wasp-like insect,[28] whose habit of parasitizing chinch-bug eggs has been discovered, but of which little further is known.

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[23] *Sorosporella uvella* (Krass.) Gd.
[24] *Triphleps insidiosus* Say.
[25] *Milyas cinctus* Fabr.
[26] *Nysius angustatus* Uhl.
[27] *Eumicrosoma benefica* Gahan.
[28] *Abbella subflava* Gir.

One of the group of round worms, commonly known as "hair snakes," occasionally destroys a few chinch bugs, but it is not numerous enough to be important.

At least 24 of the insect-feeding species of birds destroy chinch bugs along with many other kinds of insects. Quails and meadowlarks have been rated as the most important of the chinch-bug destroying birds. While these birds seldom occur in large numbers in the midst of outbreaks of chinch bugs and do not especially seek this insect in preference to others, they are a valuable enough factor in destroying this and other injurious insects to deserve the fullest possible protection.

Lizards, frogs, and toads make the chinch bug an occasional though unimportant addition to their ration. In the southwestern range of the chinch bug the so-called horned toad[29] is sometimes found with more chinch bugs than all other insects together in its stomach. Like all of the foregoing, however, it is not numerous enough seriously to reduce the chinch bug.

CONTROL MEASURES.

MEASURES MUST BE ADAPTED TO THE CONDITIONS.

Many methods for destroying chinch bugs and for limiting or preventing damage by them are given in the following pages on the basis that each may be practical at some time or place, although no one method will always be practicable. Each farmer is obliged to adapt his protective measures to weather conditions, location of field, variety and condition of crops infested and likely to become infested, available equipment, chemicals, and labor. The various methods of control are arranged on the basis of a season's campaign, beginning in the fall, as preventive measures of great importance may be started then.

Something may be done toward controlling the chinch bug during almost every month of the year, either by direct attack or by preventive measures. Continued attack on the pest at every opportunity throughout one season insures against loss the following season. Although control measures should be under way almost every month in seasons of outbreak, there are three periods during the year when the chinch bugs may be most effectively destroyed. These are: First, when they are just firmly established in winter quarters in November and early December; second, from the time the overwintering adults have concentrated in fields of wheat and other small grains until the wheat is harvested and the bugs have begun to migrate to fields of corn and sorghum; and third, from the time the corn and sorghum fields are harvested until the bugs are driven by cool weather into winter quarters.

[29] *Phrynosoma cornutum* Harlan.

EQUIPMENT.

The equipment for such work is varied and may be divided into five groups: Ordinary farm implements, sprayers and chemicals, special drags, oil-pouring devices, and gasoline torches or other heat.

FARM IMPLEMENTS.

The plow appears to be the most fundamental piece of equipment, is always available on every farm, and remarkably efficient when used to bury the bugs 7 or more inches under the surface. Following the plow closely in time of application are the harrow, drag, clod crusher, and roller. The plow is required for preparing the soil for the trench, double trench, and ridge-groove drags. In case the plow is used for making a furrow-barrier, it is followed by a log or a barrel for pulverizing the soil in the furrow. The lister may be substituted for the plow in making the furrow barrier. The post-hole auger (fig. 5) in favorable soils is the most desirable type of implement for making holes along barriers for trapping the migrating bugs. In stony ground a digging iron and a shovel will serve the purpose. The shovel, hoe, and perhaps grubbing hoe will be needed in some methods of laying oil barriers.

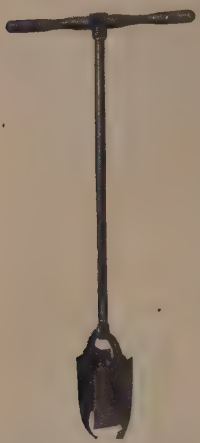

FIG. 5.—Desirable type of post-hole auger.

SPRAYERS AND INSECTICIDES.

The high-pressure, gasoline-power sprayer, though expensive, stands first in the equipment for saving an infested crop. Great care is required in selecting this outfit. Best spraying results are secured with a sustained power of 250 pounds pressure operating two leads of hose and four large-chambered nozzles (see fig. 6). This insures the largest kill of bugs, greatest economy of labor and insecticide, minimum of chemical injury to the crop, and greatest speed in saving the crop-acres. It is highly important to select a sprayer with a large pump and air chamber and good leverage or gearing system, with all valves and wearing parts easy to remove and replace. These features should be insisted upon regardless of other considerations, whether ordering a gasoline or a man-power outfit.

If the amount of spraying is large, a gasoline-power sprayer of the type shown in figure 7 should be used. For smaller areas and for spraying row crops too large to allow a gasoline-power sprayer to pass over them, a hand-power outfit of the type shown in figure 8 is entirely suitable, provided it has the capacity to maintain a pressure of 125 pounds. Smaller outfits than this are not advisable for this work, as the value of the spraying depends upon hitting the bugs,

many of which occupy relatively sheltered places. The lower pressures are suitable for young wheat, or until the crop is half grown,

FIG. 6.—Spraying chinch bugs in wheat.

or under very thorough application; the higher pressures are efficient everywhere, and are especially necessary for high wheat and rapid work.

FIG. 7.—Gasoline power sprayer in operation.

The spray-delivery system should consist of 25-foot leads of high-pressure hose, fitted with 12-foot bamboo-covered extension rods, which enable the operator to cover wide areas, thus reducing the number of trips of sprayer and horses. The rods should be, and usually are, fitted with cut-offs, by which the spray may be at once stopped when it is desired to change position, avoiding waste of material. The large chambered type of nozzle, illustrated in figures 6 and 7, will give the widest sweep of spray. It is of advantage to increase the nozzle capacity to an even greater extent by placing two of these nozzles on a Y. The nozzles must be angled, not straight, and this should be specified in ordering equipment. The hose should be trussed to wagon bed or engine cover (see fig. 7) to keep it from dragging down the wheat, especially when spraying high wheat.

FIG. 8.—Desirable type of hand sprayer.

For mixing spray preparations, especially where an emulsion is required, a good mixer is of the utmost importance. It is possible to obtain an emulsion (a uniform suspension of oil in minute particles in water) by stirring with a loop-wire, hotel-size egg-beater, or even a wooden paddle. There are, however, two or three types of moderately priced churns on the market which are so far superior to the beater as to warrant their purchase even when only a small quantity of insecticide is to be prepared. One of the best types of churn for this purpose is illustrated in figures 9 and 10. This type may be had in sizes from 3 to 25 gallons. All may be run by hand, at least up to the 16-gallon size. The larger sizes may be connected with a gasoline engine, as shown in figure 11, when a large quantity of insecticide is to be made. The churn is equally convenient for making both soap and emulsion. It may be cleaned and turned to other uses after this work is completed.

Other items of equipment incidental to spraying are a strainer with the gauze in a more or less vertical position, a pair of scales for weighing, a 1-gallon measure, and several good, clean barrels, and metal

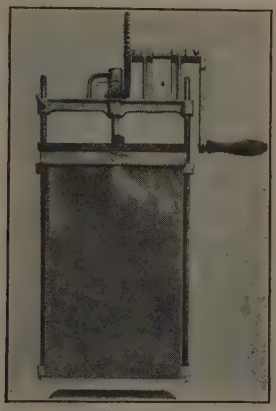

FIG. 9.—Efficient type of insecticide mixer.

FIG. 10.—Dasher removed from insecticide mixer.

drums or grain cans for storage purposes. A strainer with fine wire gauze set in as a cone is a very satisfactory type of strainer.

The insecticides required will be lubricating oil, soap, and nicotine sulphate. If the modified formula is used the nicotine sulphate may

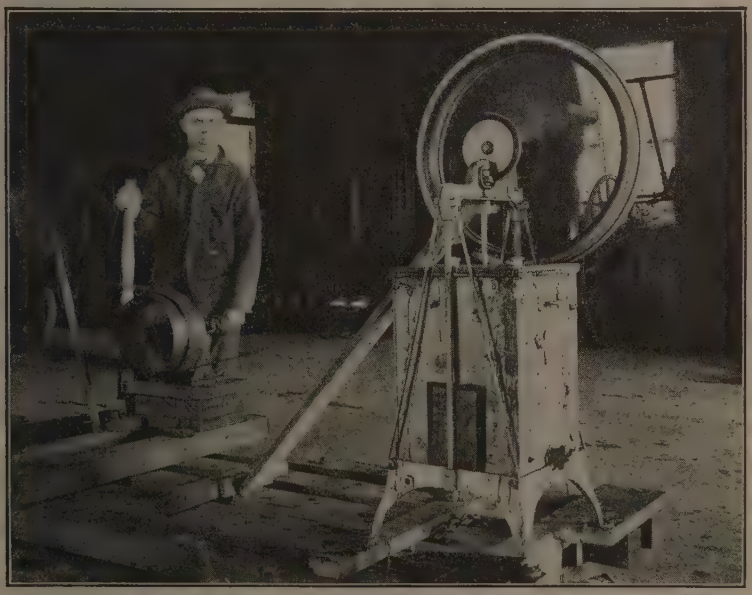

FIG. 11.—Large insecticide mixer connected to gasoline engine by means of belts and pulleys.

be omitted. The quantity of insecticides must be estimated and the orders placed early in the year to avoid delay due to heavy sales and slow transportation.

Lubricating Oil.

All of the principal oil-refining companies market an oil suitable for this purpose. The cheapest and usually lightest grade of oil is required. Its specific gravity is usually from 24° to 32° Baumé and its viscosity 200 or over. The present cost is from 38 cents to 50 cents per gallon, depending upon the quantity purchased.

Soap.

For the sake of securing an article of known strength and purity, as well as reducing the cost, the soap should be made at home. A very satisfactory soap may be made of crude corn or cottonseed oil and caustic soda, after the following formula. Cottonseed oil may be purchased of any of the cotton oil refining companies. Off-grade refined oil can sometimes be purchased as cheaply as the crude oil and is highly satisfactory. The corn oil can be purchased of manufacturers of corn products. The technical grade (78 per cent pure) of soda is satisfactory and can be purchased of wholesale drug houses.

Soap Formula.

Caustic soda	pounds	4
Water	gallon	1
Crude corn oil or cotton oil	do	2½

Directions for preparation.—Place the water in the mixer already described, sprinkle the soda in the water to avoid danger of an explosion from suddenly generated heat, and rotate the agitator slowly. *While still hot* pour the oil slowly in, meanwhile churning as vigorously as possible without splashing. *The heat developed by dissolving the soda in the water is very necessary for the formation of the soap; therefore add the oil before the mixture begins to cool.* The oil should be poured in a thin stream from a sprinkling can from which the cap has been removed, or slowly pumped in with a tin gasoline pump. Continue churning slowly until the mixture is of uniform color throughout and begins to thicken and the dasher to turn hard. Then pour into a clean barrel or other receptacle and cover for storage. Further batches may be poured directly upon the first. If properly made and stored in air-tight containers, this soap will keep for years. Evaporation should be prevented, otherwise the soap will become very hard. Galvanized-iron grain cans, with fitted lids, are excellent for storing the soap for a period of several months to a year.

Soap Liquid.

This soap, like all other hard soaps, will take time to dissolve perfectly for use in making the spray emulsion. Therefore enough should be dissolved in advance of need to make up all the stock emulsion required for the season's work. This *soap liquid* may be made by dissolving the required amount of soap in three times its weight of hot water. It should be kept in tightly covered barrels or grain cans.

Nicotine Sulphate.

This product is a highly concentrated tobacco extract, containing 40 per cent of the pure form of nicotine. It may be purchased at seed stores, drug stores, or of the manufacturers.

SPRAY FORMULA.

Either the following spray mixture or its modification will give excellent results if properly applied. Spraying may be followed by a slight amount of injury, but the wheat will recover from these apparent ill effects in a week or 10 days, and where the spraying is fully warranted will be as nothing compared with the damage the bugs would have done.

Lubricating oil	pounds	8
Soap liquid	do	16
Water	pints	7
Nicotine sulphate (40 per cent)	pound	½
Additional soap liquid	pounds	3½

To be mixed with sufficient water to make 100 gallons of spray.

Directions for Preparing Stock Emulsion.

Place the oil and soap liquid in the mixer, and stir until they are thoroughly mixed and of uniform color throughout, then add the water and continue the stirring. A creamy emulsion will quickly result, but the stirring should be continued for 15 or 20 minutes, occasionally reversing the direction of the dash, to insure thorough mixture. When the batch is completed it may at once be stored in air-tight barrels for future use. It will keep for months if the air is completely excluded. The stock emulsion should be made without heat, thus saving time and annoyance besides obtaining a preparation with good keeping qualities. It must be very thoroughly churned or stirred, so that the oil and soap will be evenly divided into fine particles and thoroughly incorporated with each other.

Directions for Diluting.

For use, first churn again thoroughly, then add water, a gallon at a time, churning after each addition, until the mixture is brought up to 10 gallons. Fill the spray tank about four-fifths full of water, stir

in the 3½ pounds of additional soap liquid and the nicotine sulphate, and start the agitator. Then pour in the emulsion while the agitator is running. In case a 50-gallon barrel pump is used this will make two sprayer loads, 5 gallons being added to 45 gallons of water and 1⅔ pounds of soap liquid previously placed in the sprayer barrel. While pouring the mixture into the sprayer the agitator should be kept moving.

A modification of the formula, in which the strength of the oil is increased by one-third, and the nicotine sulphate omitted, may be used with good results. In that case the stock mixture should be added to sufficient water to make 66 gallons instead of 100 gallons of spray, using additional soap liquid, as before, at the rate of 3½ pounds per 100 gallons.

Cost.

The cost of spraying operations for destroying the chinch bug is relatively high. The following statement of costs is the result of work done during the era of high prices prevailing in 1919.

Cost of oil per 100-gallon tank	$0.368
Cost of soap per 100-gallon tank	.653
Cost of nicotine per 100-gallon tank	.952
Total	$1.97
Cost of insecticide per acre	$29.55
Cost of labor per acre	10–13.00
Total	$39.55–42.55

In view of the considerable expense involved, the use of this method must necessarily be restricted to comparatively small areas, such as the borders or edges of newly infested fields and stubble fields or other small areas from which the bugs are migrating in large numbers.

The grower should consider well, before attempting to spray, the question of whether the expense involved will be justified by the results to be obtained. The price of suitable oils has fallen considerably since the estimate given above was prepared.

SPECIAL BARRIER DRAGS.

A dust path or oil-line barrier, laid about harvest time, between the wheat or other small-grain field which the bugs are about to leave, and the corn or other row-crop field which they threaten to attack, is one of the best means of destroying the bugs. By this means, corn planted near a small-grain field can be protected from destruction by the spring issue of bugs while still under 18 inches in height. This highly important lot of bugs being destroyed, damage from the second uprising may possibly be prevented by unfavorable weather.

THE GROOVE DRAG.

The simplest type of effective barrier, and one of the most easily constructed and maintained, is made by means of the groove drag (fig. 12). This drag makes a combination dust path and shallow ditch or groove, as shown in figure 13, both of which the bugs must cross before reaching row crops. In dry, hot weather, the dust track made by this type of drag is often of itself alone sufficient to check the migrating bugs. In wet weather, or when the bugs travel only in

FIG. 12.—Groove drag used for preparing oil-line barriers, etc.

the cool of the morning and afternoon, as they are very apt to do, it may be made impassable by laying a line of road-surfacing oil or crude creosote in the groove.

The groove drag here shown is constructed of 2 by 12 inch oak planks, 2 by 4 inch crosspieces, and an angle iron fence post with most of the base cut away. The front or clod crusher section is made of four 2-foot lengths of the plank spiked together, with the front edge of the second overlapping the back edge of the first about 2 inches, the third overlapping the second, and the fourth the third. This is reinforced by bolting a 2 by 4-inch crosspiece to each section of the plank at the middle of the front edge, and to the back of the fourth plank, a 2-inch support block being placed between the back edge of the fourth plank and the crosspiece. This section of the drag

breaks up clods and prepares the way for the smoothing section. To the back edge of this fourth plank is rigidly attached a smoothing drag consisting of two sections of 2 by 12-inch plank 4 feet long cleated together by 2 by 4-inch crosspieces near each end of the planks. To the underside of the fourth plank of the clod crusher is bolted the flanged base of the iron fence post, so placed that the two edges of the angle iron straddle the crack between the two smoothing planks, to each of which the iron is securely attached. Two strips of iron anchor the two portions of the drag together, supplementary to the angle iron. Holes are bored in the front plank of the clod crusher for the attachment of a wire anchor for a singletree for the attachment of one horse.

FIG. 13.—Dust path made by groove drag.

Equally efficient modifications of the groove drag shown in the figure have been made by substituting 1½ inch for 1-inch angle iron, and 1-inch boards for the 2-inch planks in the back or smoothing section, the two sections being fastened rigidly together. Angle iron with 2-inch sides is not satisfactory. One-inch smoothing boards are quite as satisfactory as 2-inch planks, although they are not likely to be durable. An absolutely smooth finish to the undersurface of the rear section of the drag is most necessary so that it will not catch and will produce a perfectly smooth impression. Not only must the boards be perfectly smoothed off, but the front end of the angle iron must be flattened and smoothed, and the bolt heads in it completely countersunk.

The groove drag improves the soil surface wherever used. Its width is such as to permit its use between rows of corn, thus segre-

gating infested rows and preventing the bugs from crossing into noninfested ones. It usually makes a nearly perfect barrier with one round trip on any one trail, and two or more trails may be made between corn rows in a comparatively short time. For laying an oil or creosote barrier, the groove furnishes the most economical trail, holding the oil in a narrow line and limiting any collection of oil strictly to the deepest part of the groove. Oil poured on a natural or a flat surface, a ridge, or the bottom of a plow or lister furrow, will spread out and sink into the soil, leaving a passable surface for the chinch bugs, much sooner than where its spread is limited to a groove as just described. The groove drag reduces the chance of accidentally bridging the oil line by pushing clods into it with the feet when renewing the oil. It also forms a convenient path for a two-wheeled vehicle carrying an oil container from which the oil is allowed to flow through an adjustable cock at the bottom.

OTHER KINDS OF DRAGS.

The trench drag is a special contrivance for pulverizing and compacting the soil in a furrow previously made with plow or lister. It perhaps serves this purpose somewhat better than a log or barrel, in that it fits the furrow more snugly and can be weighted as much as desired with sacks of sand. It is made of two pieces of lumber 2 by 12 inches and 2 by 14 inches, respectively, and 5 feet long; the 12-inch plank being spiked to the 14-inch one flush with one edge and at right angles with it, and the top of the drag being reinforced by a short piece nailed across each end.

A double-trench drag, making a double-barrier path, has also been successfully used. It is made of three 2 by 12-inch planks and one 2 by 14-inch plank, 4 feet long; one 12-inch piece being spiked flush with an edge of the 14-inch piece, a second 12-inch piece to the upper edge of the first 12-inch piece, and the third to the lower edge of the second. It is reinforced by a piece across each end and by two more pieces across the top and weighted as required.

The straddle drag, used for smoothing and compacting an elevated barrier made by plowing a furrow and then back-furrowing to make a ridge, is made by spiking a 2 by 12-inch plank 6 feet long flush with one edge of a plank 2 by 14 inches by 6 feet at right angles to it, the front ends being rounded off. A rectangular piece 7 feet long, cut to fit into the angle, is nailed to the inside flush with the front end, extending a foot beyond the hind end, serving to make a groove for an oil or creosote line on top of the ridge. The inside of the drag is then lined with galvanized iron. A narrow weighting platform, made by nailing three cross braces of 2 by 4 inch plank 1½ feet long across the top and fastening two planks 2 by 4 inches by 6 feet to them, completes the drag.

DEVICES FOR POURING OIL.

When oil barriers are resorted to, it becomes necessary to use containers from which a small stream of oil can be accurately directed onto the line. A 1-gallon coffee pot serves the purpose fairly well. A sprinkling can with the rosette removed is better because of its longer spout. In hot weather, when the oil is so warm as to flow freely, the spout of the watering can may with advantage be partially plugged with a stick of wood. Far more efficient than either of these, especially when the groove drag is used, is a two-wheeled truck with a 20-quart can mounted between the wheels and fitted with a stopcock at the bottom of one side. The wheels should be set about 18 inches apart. The operator walks, straddling the line, behind the truck. The stopcock is set to supply a sufficient line of oil in the

FIG. 14.—Five-torch asphalt heater adapted for burning chinch bugs.

groove. The smoothed path and this method of oiling offer a minimum risk of bridging the oil line by knocking in clods or other matter with the feet. Such two-wheeled trucks are on the market for garden spraying apparatus. Road oil No. 7 or crude creosote is considered best for this work.

TORCHES.

Gasoline torches, of the type known as the plumber's torch, are sometimes used for burning chinch bugs along dust and oil barriers. A special knapsack gasoline torch which has been used in the field for destroying trash, and incidentally the pink bollworm in the infested areas in the Gulf Region, will also be of value for destroying the bugs massed along barriers. Neither of these types of torch is of much value for burning the bugs in growing crops or in stubbles.

A five-torch asphalt heater (fig. 14), generating a temperature of 230° F. at the surface of the ground, also has proved inefficient when

applied to green sorghum stubble. It is expensive in its consumption of gasoline and will not kill bugs sheltering under small clods of earth or in the stubbles of kafir or sorghums. Where such apparatus happens to be available, it might be useful in destroying bugs trapped along barriers. It might have a further value in burning the stubble of small grains immediately after the crop is harvested and before the bugs have completed their migration to other crops. The asphalt heater is made for use on paved streets, and to be operated by man power. To make it applicable to cultivated ground, it is necessary to attach shafts to the handle end and to swing the torches 2 or more inches higher on the running gears than would be necessary on the street, in order to avoid clogging them with earth.

Of all heat application, the most effective in destroying chinch bugs is the heat furnished by the sun and absorbed by the soil. The surface of the soil not infrequently registers temperatures so high that the bugs can not survive even a few minutes' direct exposure, soil temperatures from 130° to 150° F. having been recorded in Kansas and Oklahoma. When caught for a few minutes in a dust furrow or groove barrier heated to such temperatures by a bright summer sun the bugs invariably are killed.

THE SEASON'S CAMPAIGN.

FALL CLEAN-UP.

A general clean-up in the fall is important to prevent as many bugs as possible from successfully entering into hibernation. All corn and sorghum stalks and stubble should, where practicable, be plowed under to a depth of at least 7 inches and packed with roller or drag, so that the bugs can not escape. This should be done as promptly as possible after the corn or sorghum is harvested and before the bugs begin to migrate to their final winter quarters. Wherever bunch grasses grow on strips of waste land about the farm which will permit deep plowing, the land should be plowed as above described.

Bunch grasses growing in meadows, pastures, and ravines and along roadsides should be burned, preferably soon after the first freeze.

The trash, consisting of grasses, dead leaves, etc., occurring in hedges, brushy fence rows, brier patches, and woodlands should likewise be put to the torch. This destroys the usual hibernating shelters of the bugs, without which few can survive the winter, and results in the death of from 50 to 90 per cent of them. *Where burning operations are conducted in proximity to woodlands, the most careful precautions should be taken to prevent setting fire to the timberland, as otherwise disastrous forest fires may result.* The fullest possible value of burning can only be secured by concerted action on the part of all the farmers of an infested area in the months of November and December. A good torch for ignition purposes is made by fastening

a bundle of soft cloth in the twisted-wire holder of a mop stick and saturating it with coal oil. Either of the types of blow torch previously mentioned will also serve.

FOREWARNED IS FOREARMED.

In March a field-to-field examination of little bluestem and other bunch-forming grasses conducted over a large sheet of newspaper or oilcloth will enable the farmer to form an opinion of his chinch-bug prospects. If he finds several or many bugs in each bunch examined he will do well to defend himself against these wintered-over insects getting into his wheat, and prepare his equipment for spraying or the laying of barrier lines.

TRAP STRIPS BETWEEN WINTER QUARTERS AND WHEAT.

A strip of wheat, millet, oats, or rye placed between infestations in bunch grasses and other wintering places and the nearest fields of small grains will usually attract the bugs and prevent them from scattering widely. In April this trap strip should be watched closely so that it may be destroyed when its infestation is greatest. If such trap strip be not planted in time to attract the bugs, or if not planted at all, the edges of wheat fields nearest to areas of bunch grasses, pastures, roadsides, and ditch banks should be carefully inspected every few days, beginning about mid-April. As impending serious outbreaks are most likely to be first discovered in wheat fields shortly before harvest, when the overwintered adults have their first summer generation well under way, it becomes expedient and decidedly profitable to discover the bugs early.

TRAP STRIPS BETWEEN WHEAT AND CORN.

May is the time for planting any trap crop intended to protect corn and sorghum from the bugs migrating from wheat ripening in June or early July. Occasionally this trap may be planted in June and still make enough growth to have real value. Millet and cane are suggested as the best crops at this time. To be most serviceable, this trap crop should be between the infested wheat and the corn or sorghum to be protected, should be at least one drill-width, and should be seeded early enough to allow a growth of 4 to 6 inches before the bugs begin to migrate. The bugs in the trap strip should be destroyed when the largest possible number is present and while the plants are still succulent. They may be killed by plowing the strip 7 inches or more deep and firming the soil with drag or roller, or they may be killed by spraying.

SPRAYING THE BUGS IN WHEAT.

As soon as mating has become common, it may be assumed that sufficient migration from winter quarters to wheat has occurred to warrant spraying with the formula given on page 21. If at this time the infestation in the wheat extends over only a narrow margin of the field, before spraying is attempted it will be advisable to determine whether it may be less costly to plow the infested strip under to a depth of at least 7 inches, beginning at the innermost infested row, and immediately harrow and roll or drag it. If an efficient type of sprayer and a supply of insecticide are immediately available, however, the bugs may be effectively destroyed by spraying. In May or early June, depending upon locality and season, the bugs developing in the wheat should be sprayed. As already stated, the spraying should be done after the bugs begin mating and before the wheat is in full head. The smaller the wheat is when sprayed the greater the saving in time and spray material and the larger the number of bugs that will be killed. Hence, after the bugs are heavily massed on the wheat, the sooner the spraying is done the better. It is important to remember this fact, that only those bugs hit by the spray will be killed, and therefore thorough application, using plenty of liquid at high pressure, is absolutely necessary. From 1,500 to 2,500 gallons of spray material per acre will be required, depending on the height of the wheat.

Infestations in rye, barley, and oats should be treated the same as those in wheat.

While the bugs usually begin to leave the wheat for the nearest cornfield about 10 days before harvest, it sometimes happens that a vast majority of them remain in the wheat until it is cut. In such cases they may be destroyed and consequent injury to the corn prevented by spraying them in the stubble along the margin of the field immediately following the binder.

SPRAYING THE BUGS IN CORN AND TRAP CROPS.

As soon as the migration from the wheat has ceased, the bugs on the early summer trap-crop standing between wheat and corn, if such trap planting has been made, should be destroyed. One of the most effective ways of doing this is by spraying. As there is no need for saving this trap-crop, the spray mixture may be strengthened up to 3 per cent, or a strong mixture of kerosene and water used. Unless a sprayer and solution are immediately available, however, the trap-crop should be plowed under deeply and the ground firmed immediately thereafter.

To destroy chinch bugs in corn by spraying on a broader scale than merely the first few heavily infested marginal rows, is much

more difficult than to destroy them by spraying in the wheat field. On the completion of the wheat harvest, corn usually is of such size that it is difficult to get over the field with the sprayer. If they have been allowed to enter the field, the bugs will be sheltered beneath the leaf sheaths and in the ground about the roots, some being entirely inaccessible. Thus, to insure hitting most of the bugs it is necessary to soak the plants at high pressure. The excessive amount of spray material necessary to reach the interior of the leaf sheaths is very likely severely to injure the plants. While the corn is under 3 feet in height, much good may be done by spraying all of the area where the bugs are numerous, even if that should be the whole field. At that time the bugs are less securely sheltered and much less liquid is required to cover them. Nevertheless, injury to the corn may be expected, although it may not be as severe as would be inflicted by the bugs. The precaution should be taken to spray only in the mornings and evenings or on cool, cloudy days, in order to avoid excessive injury to the plants. Some injury will probably result anyway, but the plants usually will recover inside of a week or two.

SUBSTITUTING NONSUSCEPTIBLE CROPS FOR CORN AND SORGHUM.

Before starting to plant corn or sorghum the farmer should know if any substantial infestation exists in near-by wheat, and if so he should be adequately prepared to defend his crops from the bugs or else substitute nonsusceptible crops for corn and sorghum. A nonsusceptible crop, such as those listed below, even if not as profitable as a crop of corn, may be far more profitable than a chinch-bug-damaged crop of corn.

The chinch bug depends entirely upon grasses and grass-like plants, including corn and small grains, for food. The spring brood must have wheat and other small grains or grasses to live upon from the time of emergence from hibernation until corn or similar row-crops are of a size to meet its needs. If the growing of corn and sorghum could be stopped in the semiarid regions of the West, bugs of the summer generation would be practically starved out and unable to attain serious numbers, and wheat would accordingly cease to be injured appreciably. Likewise, if the growing of wheat could be stopped, bugs of the spring generation would not have sufficient food on which to develop and would consequently do no great damage to corn. Such measures, however, are usually impracticable.

A threatened outbreak may be avoided by substituting for corn a leguminous crop on which the bugs will not feed. As early as 1785 some districts in North Carolina suffered such losses in wheat by chinch bugs that wheat production was abandoned. In 1809 the farmers of Orange County, N. C., cooperatively resorted to the

method of planting no wheat for two successive years and were satisfied that they destroyed the chinch bug by so doing.

On the following crops the chinch bug will not feed: Cowpeas, soy beans, velvet beans, clovers, peanuts, stock beets, sunflowers, and rape. The crop or crops chosen for substitution must of course depend on the locality, the prevailing local conditions, and the markets.

OPERATION OF BARRIERS.

As the wheat ripens, beginning about 10 days before harvest, the bugs become restless. Some climb the ripening stems and continue to suck juice from the plant as long as there is any greenness at the upper nodes and in the head. Others wander away, finding succulent vegetation somewhere, most conspicuously in the nearest cornfield. At this time, speed in action against the bugs is vital. Those corn growers who have not destroyed the bugs before this migration should then devote their best attention to the pest until they have destroyed it. To temporize with it is to lose some of the crop and much time.

If the insects have not as yet been controlled by spraying in the margin of the field of young wheat, or by other methods previously recommended, the quickest efficient barrier that can be constructed should be thrown up against them. The groove drag, if made in advance, in anticipation of chinch-bug trouble, will be the quickest barrier maker. Usually the ground is dry when migration begins; if rainy, the wheat continues juicy and migration may be delayed. The trench, double trench, and ridge groove or straddle drags require preliminary soil preparation with a plow or lister before they can be applied. The same is true before a log or barrel can be used. These several barriers are made in the following ways: (1) A deep furrow is plowed along the sides of the field from which the bugs are threatening to invade the corn, the soil being thrown toward the infested field. A second run of the plow may be necessary to obtain sufficient depth to stop the bugs. The sides and bottom are then reduced to a covering of fine dust by dragging repeatedly back and forth in the furrow, a trench drag, a barrel, or a log. (2) The furrow may be made with a lister, the soil being thrown both ways, and the surface pulverized as described above. (3) A strip of ground is disked and rolled or dragged until there are several inches of fine, loose soil and dust, and a furrow is made by means of the trench or double trench drag. (4) A ridge is made by throwing two furrows up together, and is then pulverized and grooved by means of the ridge-groove or straddle drag. In applying barriers against the migrating bugs, it may be necessary or at least expedient to construct a second barrier or even a third. The additional barriers will

not be necessary if the first barrier is made at the edge of the field before any bugs have crossed the line and is maintained in an impassable condition until migration has ceased.

The barriers mentioned above are all dust barriers and are effective only when dry. In case of a shower a crust is formed on them over which the bugs can walk without hindrance, until the soil dries enough to allow redragging. As quickly as the shower is over, oil or crude creosote may be poured in the groove of the groove-drag barrier or in the bottom of the trench barriers and in the groove of the ridge barrier. Very good results have been secured by throwing up a ridge, as indicated in method (4) above, and applying crude creosote *in a line three-fourths of the way up the ridge* instead of along its summit. Oil, to be effectual, must be kept soft in a continuous line during every minute that the bugs are trying to cross the line. This requires several treatments during the first 24 hours, until the oil has made a hardened crust for itself, after which two treatments a day may be sufficient to keep the line continuously impassable. An oil line in the floor of a trench barrier is very apt to become defective or passable from the falling of clods from the sides of the trench into the oil.

Where special tools are not available smooth paths may be made along edges of a field by the use of a shovel, perhaps aided in places with a hoe or grubbing hoe, the path patted down with the back of the shovel, and an oil line laid on this path. The cost of labor with this type of barrier is likely to be much greater than with the other types.

DESTROYING THE BUGS ALONG BARRIERS.

As the bugs accumulate along the barriers some will be killed by the combined heat of sun and soil and suffocation by the dust. Large quantities can be killed by gasoline torches without disturbing the efficiency of the barriers, and burning as often as the massing of the bugs warrants is an effective way of destroying them. Another way to collect and destroy them is by digging holes at intervals of from 15 to 30 feet with a post-hole auger on the bug side of the barrier, the edge of the hole touching the edge of the oil line or the foot of the slope in the trench and ridge barriers. As the bugs come to a line which they can not cross they follow it and fall into the holes. If the holes are 12 to 18 inches deep, the bugs massing therein may die without further treatment. It is necessary, however, to watch that they do not climb out on trash blown into the holes. They may be killed by pouring a little coal oil into the holes, by burning, or merely by tamping. One difficulty with the postholes is that along the dust barriers they have to be remade with each renewal of the barrier.

Bugs may be trapped along barrier lines by laying 8-inch sections of green cornstalk close to the line 6 inches to 6 feet apart, depending upon the number of bugs, then quickly tapping the bug-laden pieces over a bucket half full of water overlain with a film of coal oil. The bugs should be collected in this way as frequently as their numbers on the stalks seem to warrant. The pieces of stalk will continue attractive for two or three days.

The barrier work should not be substituted for an aggressive all-year campaign, but should be regarded rather as a play for time on the part of the grower. While many bugs are killed by the proper care of barriers (their numbers being estimated in bushels where catches in post-holes have been most successful), at best the barriers leave large numbers of bugs alive to migrate anywhere except across the barrier, and some will even succeed in crossing unless the greatest care is taken to keep the barrier line free from trash.

PLOWING THE BUGS UNDER IN WHEAT STUBBLE AND CORN.

With the harvesting of the small grains, spraying or deep plowing of the stubble should be rushed before the last of the bugs have left the "pigeon-grass" and other green grasses growing in the stubble field. In case some of the bugs have succeeded in starting an infestation on the first few rows of corn and the latter is small enough to plow under completely, it is best to sacrifice those several rows by plowing them under. Plowing should be at least 7 inches deep and the ground should be immediately dragged and rolled, to compact the soil so that practically no bugs can escape. It is possible in the case of a small field, where the corn is too large to plow down and there is no spraying equipment available, to destroy the bugs in heavily infested first rows by cutting and submerging the corn quickly in a tub of water coated with one-fourth inch of coal oil. The plants must be handled gently in cutting and lifting over the coal oil, as the bugs will drop to the ground on comparatively slight disturbance.

Under favorable conditions, a second brood of bugs usually occurs in the corn, resulting in prematurely deadening the stalks in late August, or in September. As quickly as the crop is harvested, plows should be started on the fall clean-up, overtaking as large a proportion of the winged adults and nearly mature young as possible, before they leave for their winter quarters. This completes the year's round of opportunities for chinch-bug destruction.

COOPERATION.

It may be observed from the foregoing recommendations that the destruction of the bugs at every period of the year, and by every known practice, has been advocated on the basis that the best means

adaptable under the circumstances shall be used. It will be observed also that plans for evasion of losses from chinch bugs are presented in crop rotations and nonproduction of continuous-season host crops. *Cooperation is absolutely necessary* in order to obtain the fullest possible value from any method or combination of methods which may be used.

First, there should be team work in surveying the neighborhood for possible pests. Growers should be continuously alert to discover the chinch bug, and other important crop pests as well, before such pests have begun their raids. Exceptional abundance, or even the mere presence of any unusual insect which may prove harmful, should be brought to the attention of their neighbors and the county agent or the nearest entomologist. Where possible this information should include the name of the pest, its host plant, or its place of occurrence, and an estimate of its abundance. If it is plainly injuring a crop this fact should be stated. If its name is not known, specimens should be sent to the county agent or other authority, together with the name and address of the owner of the property where the suspected pest or the infestation occurs.

Second, on discovering a threatened or actual outbreak a conference of the farmers and the county agent in the threatened area, and, if possible, a State or Federal entomologist, should be held to plan the best possible campaign of control and to determine what equipment and chemicals are on hand or what must be purchased, either cooperatively or by individuals. There should be agreement upon the time to strike and the duties of each person concerned. Each man should definitely understand his duties, and agree to work simultaneously with his fellows so that their combined effort will either destroy a known center of infestation or at least place the pest under the most efficient control in that area or neighborhood. It is not enough merely to limit the direction of spread of the pest to a point away from the fields of the cooperating community. As an illustration, consider an extremely infested wheat field close to a county or State line. Cooperation is apt to be unusually difficult in such a neighborhood because two county organizations are involved. It is none the less vital, however, to have cooperation. To guard against the movement of the bugs to properties lying adjacent on one, two, or even three sides in the one county, and allow them to escape to property on the fourth side simply because that property is in another county, merely postpones and multiplies the trouble. Let us suppose the farmers in one county have cooperated with regard to purely defensive measures, causing bugs to migrate to adjacent fields in the adjoining county. The dispersion will furnish material for new infestations which will reinvade the territory

originally occupied by the bugs, just as soon as the artificial barriers are removed and attractive crops appear. This may be within a few days, a few weeks, or the following years.

It will cost the farmers much less to help a neighbor in the purchase of the labor and supplies necessary to make an immediate aggressive attack, and thus wipe out an infestation when first discovered on his place, than to allow it to cross property lines, multiplying the needs of equipment and labor, and increasing the losses caused by the bugs.

While it is reasonable that a farmer should stand the loss of his own crop by an infestation of bugs first observed on his land, it is sometimes well worth while for his neighbors to consider the advantages of appraising with him the value of his damaged crop, mutually bearing the loss and the cost of the campaign, and to destroy immediately both crop and bugs. There are times when the destruction of a damaged crop will be cheaper by plowing and dragging than by any other method, and when plowing is thorough, at least 7 inches deep, and is immediately followed by thorough harrowing and dragging, the kill thus secured is nearly 100 per cent.

Third, the community adoption of growing crops which are not susceptible to chinch bug injury, in order to break the continuity of host crops over large areas, may sometimes be advisable.

Fourth, team work is absolutely necessary to secure thoroughgoing benefits from the important work of burning the chinch bug hibernating places. Complete and thorough burning of the bunch grasses in November and December, undoubtedly a very valuable measure, can be accomplished only where there is cooperation. Burning in patches and at different dates, even if ultimately thorough and distinctly beneficial, leaves opportunities for the escape of the unburned bugs. Bugs whose cover is burned on one farm may transfer to nonburned cover, and again move if that is burned; whereas, if all the fields, etc., are burned at one time, at the earliest date practicable after vegetation is killed by frost, the surviving bugs generally will be killed by exposure to the winter weather.

In conclusion, it should be fully recognized that the chinch bug, even though it may not now be abundant on your own farm, is a very potential crop destroyer, and with favorable weather may rapidly become injurious over large areas. The fact that your neighbor is the loser to-day makes it most probable that you will be the chief loser to-morrow. It can not be too strongly urged that you at once ally yourself with your neighbor, determine upon your course of procedure, and *stop the chinch bug right where it is to-day.*

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